G.I.S. & R.D.B.M.S. USED WITH OFFLINE F.A.A. AIRSPACE DATABASES

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ABSTRACT

A geographic information system (GIS) and relational database management system (RDBMS) were used in a Macintosh environment 'to access, manipulate, and display off-line Federal Aviation Administration (FAA) databases of airport and navigational aid locations, airways, and airspace boundaries. This proof-of-concept effort used data available from the Adaptation Controlled Environment System (ACES) and Digital Aeronautical Chart Supplement (DACS) databases to allow FAA cartographers and others to create computer-assisted charts and overlays as reference material for air traffic controllers. These products were created on an engineering model of the future GRASP (GRaphics Adaptation Support Position) workstation that will be used to make graphics and text products for the Advanced Automation System (AAS), which will upgrade and replace the current air traffic control system. Techniques developed during the prototyping effort have shown the viability of using databases to create graphical products without the need for an intervening data entry step.

1. BACKGROUND

Currently, FAA cartographers support air traffic control operations at Air Route Traffic Control Centers (ARTCC) throughout the country by performing many charting functions; two of the most important are hand-drawing charts and creating information overlays for pre-printed national aeronautical charts. These cartographic products are available for reference in light boxes positioned above the air traffic controllers' radar scopes. The future Common Consoles of the AAS will have electronic display monitors instead of light boxes; paper charts and acetate overlays will be replaced by electronic charts and overlays. The change in display technology requires a change in product-generation techniques. Instead of polygons being hand-drawn as inked lines, polygons will be derived from a file of coordinates and displayed on a computer monitor, Thus, the techniques used to make cartographic products will be updated through use of an off-line computer workstation, currently called the GRASP (Clark, et al, 1993), and will be oriented toward cartographic applications in support of the AAS. Instead of cartographers using printouts of coordinate data from many sources as reference for hand-drawn products, they will use electronic coordinate data from their ARTCC's central computer or from national-level sources, such as the National Oceanic and Atmospheric Administration (NOAA). They will download these data to their off-line workstations and access the data locally, and use only that portion that specifically relates to the immediate task. The resulting softcopy product will be uploaded through translators to the central computer to support the controller at each individual Common Console.

2. PROBLEM

The AAS requires computerization of cartographic functions because cartographic products will be electronically displayed. The key issue for FAA cartographers and other staff members, such as airspace-and-procedure specialists, is how to develop new methods for automating the current, manually intensive techniques needed to create cartographic products. This issue applies whether the products will be used directly for air traffic control operations, for reports, or for the negotiated, legal agreements bet ween air traffic control facilities regarding the use of airspace. Airspace information is made available in a variety of FAA aeronautical publications that are issued every 56 days. Information used during one cycle could be significantly obsolete by the next cycle. Federal law requires that any map graphics used by controllers conform to currently' published data. Changes at present are made by manual updates to hand-drawn charts, with the changed information being available through visual inspection of change notices and other government publications. Changes must be made in individual drawings, and the process is time-consuming.

3. METHOD

Preliminary use of the GRASP engineering model (GRASP/EM) (Clark, et al, 1993) by FAA staff at the Atlanta, Washington, and Seattle ARTCCS resulted in numerous products used in reports, and in the so-called "letters of agreement" (LOA). LOAs are negotiated between adjacent ARTCCS or between air traffic control sectors and adjacent airports within ARTCCS in order to assure the safe hand-off of aircraft as they pass from the control of one controller to another. The graphical products for LOAs or other uses were constructed from the effective, though laborious, hand-entry of coordinates and miscellaneous information into text-files as input for the GIS of the GRASP/EM. A multilayered GIS was built in this way and was the basis of initial products. But after the initial products came the realization that changes to the database would be necessary periodically. And there was also the desire to add additional sources of data to the database.

The voluminous data available in the FAA databases can be very useful to users of the GRASP/EM. One database, the DACS, is sent to every ARTCC on IBM PC-formatted 3 1/2 inch diskettes every 56 days by NOAA, The 2-disk set, containing location information about the paths of airways and navigational aids along those airways, is valuable for aeronautical chart overlays used in air traffic control operations, as well as in legal agreements and peripheral cartographic products. The ACES database, also updated on a 56-day cycle, is built or adapted locally at each ARTCC from data provided by the FAA's National Flight Data Center; ACES data are well suited for the same purposes as DACS data, having the added advantage of including defined boundaries of airspace specific to that ARTCC.

DACS and ACES data files were accessed and processed using the Microsoft FoxBASE RDBMS, then displayed and edited using the MapGrafix GIS developed by ComGrafix of Clearwater, FL. The RDBMS provided a convenient and effective SQL-like programming and database management tool for accessing the tabular text data and reformatting into the correct form for the GIS. The relational capabilities also were used in order to link the node names of one ACES file to the location coordinates of those nodes in another ACES file. The screen-building feature of the RDBMS was used to create the user interface for choosing what DACS or ACES data to process, Other screens allowed the user to choose the latitude and longitude range of data to be output, and to select various parameters for the GIS. The RDBMS was used to format the processed data as a text-file that was directly compatible as input for the GIS. DACS data of airways, navigational aids, and identifiers were processed and displayed at the national level, with all (unedited) airways on one GIS layer, as shown in Figure 1, Using the GIS, a portion of the national data could be displayed at the local level with all airways and edited ancillary information on several layers, as shown in Figure 2.

The cartographers and airspace-and-procedure specialists at all three of the GRASP/EM test sites built master databases. They developed these databases with numerous GIS layers populated with polygons, line segments, symbols, and text annotation graphically describing the airspace controlled by their ARTCC. Figure 3 is an example of one of the databases. For clarity at the scale of this paper only four of the possible 72 layers are shown (the data definition for the whole, detailed GIS required over 350 pages of text). The goal while building and revising the master databases was to make the data easily accessible and adaptable for custom products; therefore, each type of information, such as navigational aid, airport, airway, or textual annotation, was placed on a separate layer. Figure 4 illustrates that various layers. can be selected to create overlays for aeronautical charts for specific air traffic control sectors. Selective use of the many layers created at the Atlanta ARTCC has resulted in custom overlay products being created for several airspace sectors for evaluation by controllers. In Figure 5, airway information from the DACS portion of the database was selected and added to specialized airspace data that had been entered manually to the database. This information was used to create graphics for memos and reports regarding specific areas of airspace.

Until the GRASP/EM was evaluated by FAA staff in the field, overlays, charts, and graphics for reports and legal agreements were generally hand-drawn. However, cartographers at the Atlanta ARTCC had automated all their locally-produced charts and drawings with the FAA-supplied AutoTrol computer-aided-design (CAD) system called the Computer Assisted Engineering

Graphics (CAEG) , system. With the CAEG, which has been used to create many useful products, manual input of coordinates for each point is required. Yet, the database thus created has no common foundation and updating any chart on this system is done to the individual chart. But prototyping efforts with the GRASP/EM suggest that the GIS system of the GRASP will afford the cartographer with a rapid data updating capability. And the database management system will ensure that all charts created from the common database will be current.

4. CONCLUSIONS

The use of RDBMS and GIS software in a desktop/workstation environment, in this proof-of-concept effort, was an effective means for beginning to transfer cartographic-type tasks from the traditional pen-and-ink domain to the computer-assisted mode that will be expected of FAA cartographers and airspace-and-procedure specialists in the future. Databases that are periodically distributed by data sources at the national-level were effectively accessed, manipulated, and displayed by staff members at the local-level ARTCC test sites. Users of the GRASP/EM created overlays as reference material for air traffic controllers using computer-assisted methods as well as manual data entry of information to create the products. The overlays to aeronautical charts are being evaluated by controllers to determine if they are acceptable for daily use during air traffic control operations. Techniques developed during the prototyping effort have shown the viability of using electronic databases to create graphical products, minimizing the need for time-consuming manual data entry followed by tedious checking for errors.

The GRASP/EM will be superseded by an operational' GRASP system supplied by a commercial vendor.

5. ACKNOWLEDGMENTS

The authors wish to acknowledge the cartographers and airspace-and-procedure specialists at the Atlanta, Washington, and Seattle ARTCCs who have been utilizing the new technology provided by the GRASP engineering model. Their efforts are providing the valuable proof-of-concept products that will assist in developing and serving a more modern air traffic control system.

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6. REFERENCES

Clark, Jerry, Richard K. Fretz, Dr. Nevin A Bryant, Dr. Thomas L. Logan, 1993, A New Tool for FAA Cartographers, *Technical* Papers , ACSM / ASPRS Annual Convention and Exposition, New Orleans.

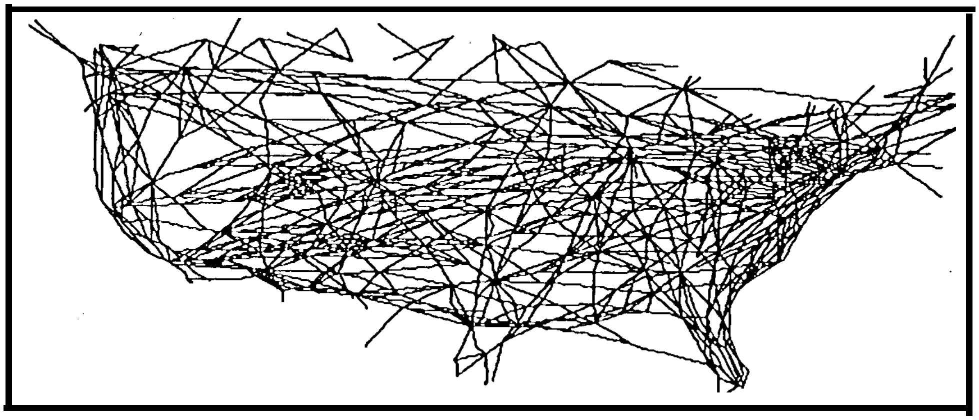

Figure 1. National-level map of high-altitude airways
derived from processing of electronic DACS version of tabular files.

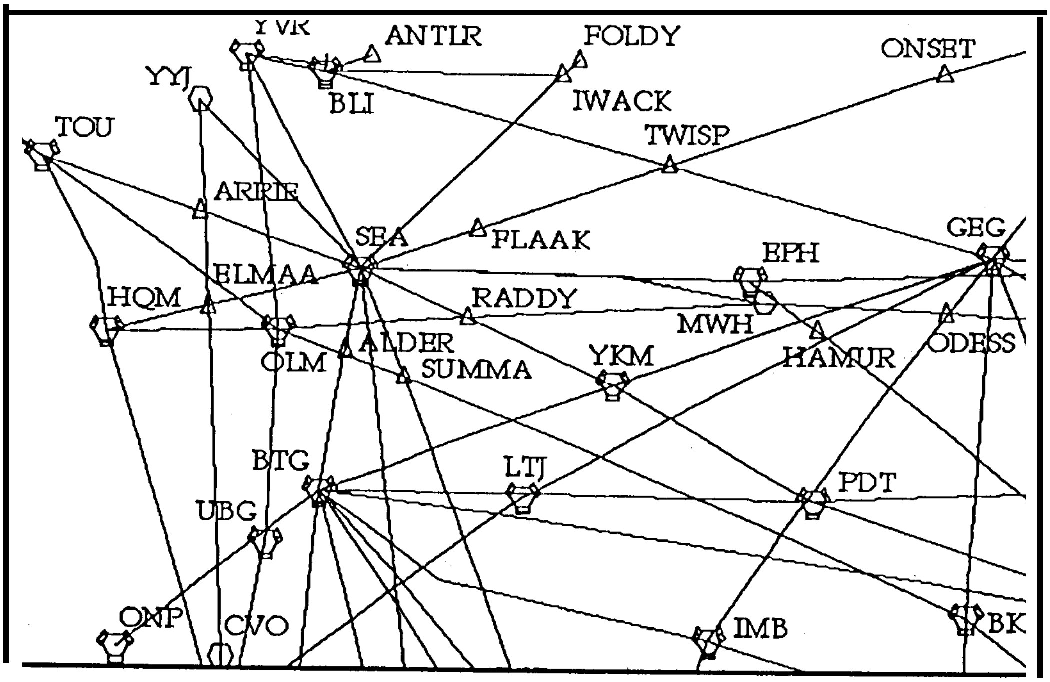

Figure 2. Localized map of DACS high-altitude airways,
navigational aids, and annotation in the Seattle area;
annotation was spatially-edited in the GIS.
(Note the SEA, OLM, and YKM designations for the
Seattle, Olympia, and Yakima navigational aids.)

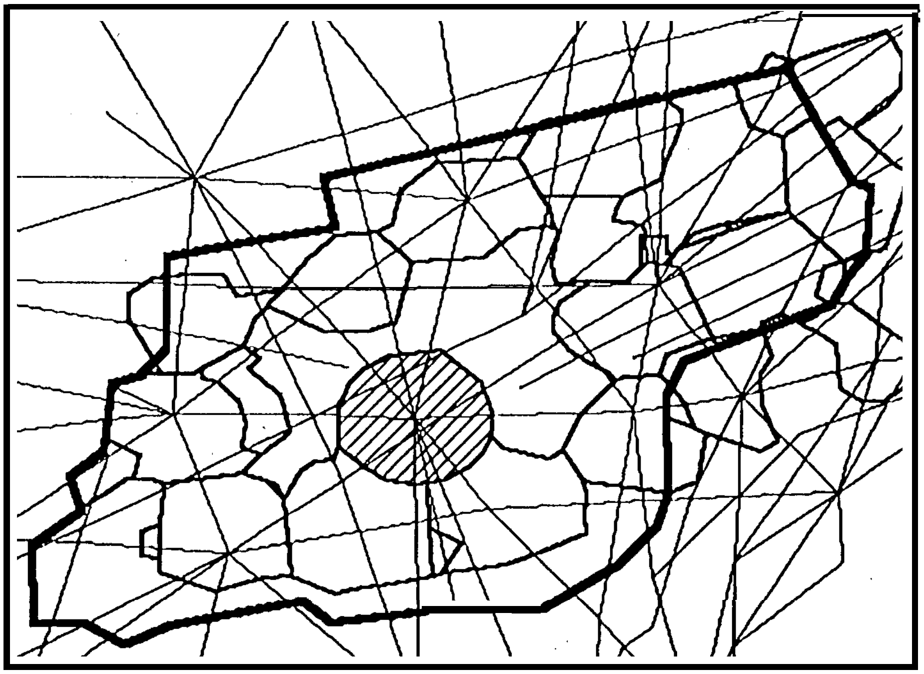

Figure 3. Composite multilayer, multi-source Atlanta ARTCC GIS database, with selected layers showing high-altitude routes, numerous Approach Control boundaries, and ARTCC boundary.

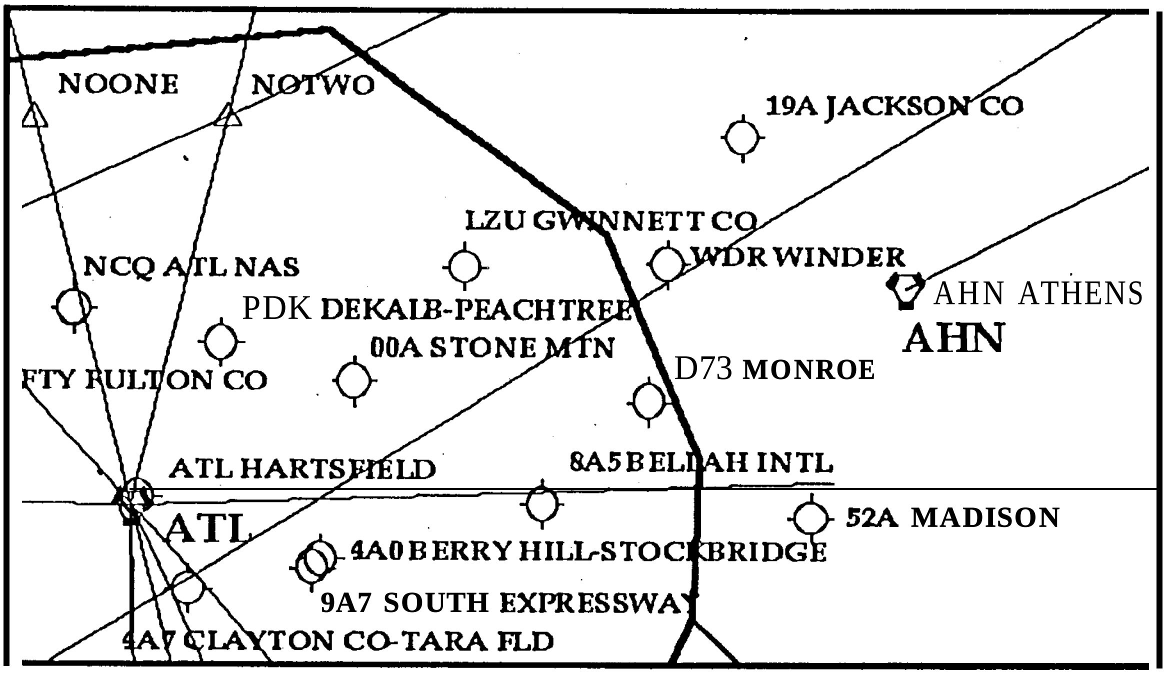

Figure 4. Extracted portion of Atlanta ARTCC GIS database, available for air traffic control operations, with selected layers showing high-altitude routes, symbols and annotation for airports and navigational aids, and Approach Control boundaries. (Note the AHN and ATL designations for the Athens and Atlanta navigational aids.)

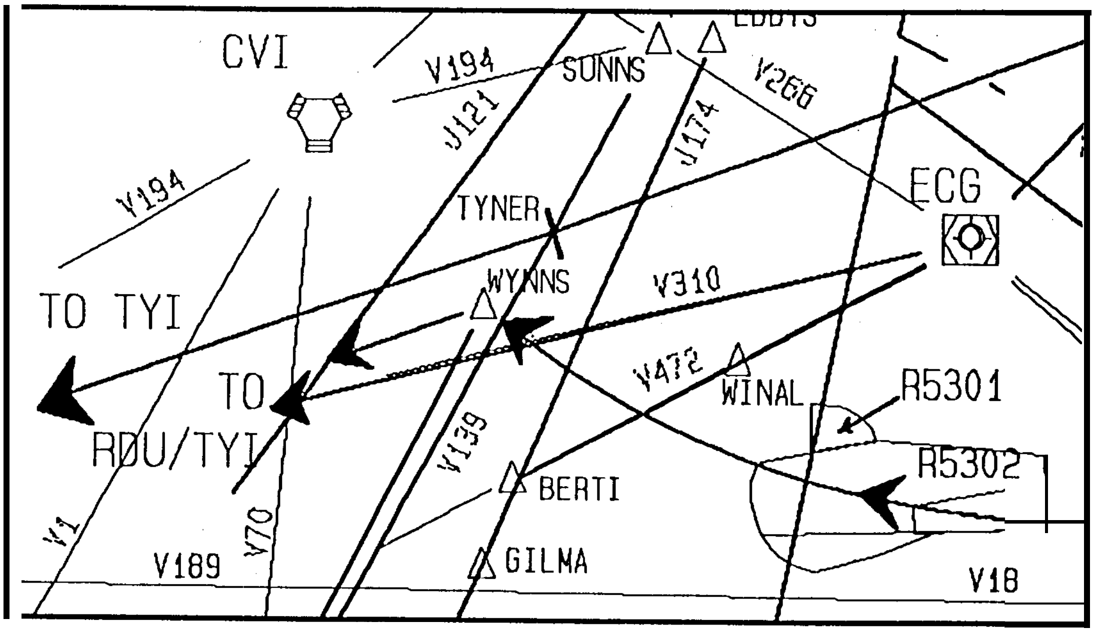

Figure 5. Extracted portion of multilayer, multi-source Washington ARTCC GIS database, used for Letter of Agreement between the Washington ARTCC and Oceana, VA, Air Traffic Control Facility, with layers selected for high-altitude ("J") routes and low-altitude ("V") routes, aircraft departure routes, navigational aids, miscellaneous airspace, and respective annotations.